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Learning Styles and the Use of Multiple Representations in Basic Electronic Lectures for Physics Education Students: A Critical Study

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Abstract: *Physics education graduates will produce quality teacher candidates. However, physics education students have difficulty understanding basic electronics lectures. Multiple representation-based lectures are needed to improve students' cognitive understanding and skills. This representative multiple is adapted to student learning styles. The problem comes from the lack of references that explain the learning styles of prospective physics teacher students with multiple representative integrated basic electronics lectures. The problem formulation that arises is how students' learning styles are presented and how basic electronics lectures are represented. The method used is mixed methods with a data triangulation design. Quantitative data comes from questionnaires of 50 students and qualitative data comes from interviews with lecturers teaching basic electronics courses. This research was conducted at a university in West Sumatra. The research results show that student understanding is still low and research needs to be carried out regarding the development of basic electronics programs based on multiple representations to improve students' cognitive understanding.*

Abstrak: Lulusan pendidikan fisika akan menghasilkan calon guru yang berkualitas. Namun, mahasiswa pendidikan fisika mengalami kesulitan memahami perkuliahan dasar elektronika. Beberapa kuliah berbasis representasi diperlukan untuk meningkatkan pemahaman dan keterampilan kognitif siswa. Kelipatan representatif ini disesuaikan dengan gaya belajar siswa. Masalahnya berangkat dari kurangnya referensi yang menjelaskan gaya belajar calon mahasiswa guru fisika dengan beberapa perkuliahan elektronika dasar terintegrasi yang representatif. Perumusan masalah yang muncul adalah bagaimana gaya belajar mahasiswa disajikan dan bagaimana perkuliahan dasar elektronika direpresentasikan. Metode yang digunakan adalah metode campuran dengan desain triangulasi data. Data kuantitatif berasal dari kuesioner 50 mahasiswa dan data kualitatif berasal dari wawancara dengan dosen yang mengajar mata kuliah elektronika dasar. Penelitian ini dilakukan di sebuah universitas di Sumatera Barat. Hasil penelitian menunjukkan bahwa pemahaman siswa masih rendah dan perlu dilakukan penelitian terkait pengembangan program elektronika dasar berbasis multiple representation untuk meningkatkan pemahaman kognitif siswa.

INTRODUCTION

Education is a basic need that is very important in shaping the character and abilities of individuals. Education can develop self-potential, gain knowledge, and skills needed to contribute positively to society. Every child has the right to access quality education, not only covering academic aspects, but also emotional and social development. (Sundari, 2024; Yulianto, 2024).

The importance of education also lies in its ability to open up opportunities and improve the welfare of individuals and society as a whole (Barella, et. al., 2024; Mihit, 2023). The younger generation can be ready to face global challenges, innovate, and adapt in an ever-evolving world through education. Investment in education is an investment in the future of the nation so that it can compete with the world community. Including physics education which will produce physics teachers.

Physics education plays a crucial role in building the foundation of scientific understanding. Students are encouraged to develop critical and analytical thinking skills needed to solve complex problems (Febiola, et. al, 2023; Akhmad, et. al., 2023). Mastery of physics is a gateway to many fields of science and technology. A good physics curriculum should be designed to be a practical experience through experiments and projects. One branch of science in physics is basic electronics.

Basic electronics lectures are essential in the digital era. Almost all aspects of modern life depend on electronic devices. Through basic electronics education, students are equipped with an in-depth understanding of basic components such as resistors, capacitors, and transistors, as well as how more complex electronic circuits work. The importance of this lecture also lies in providing practical skills, such as designing and analyzing electronic circuits, and integrated with technology learning (Dwijayanthi, 2022). Students who study this field will be able to develop innovative solutions in information technology, telecommunications, industrial automation, and many more. The electronics lecture curriculum must be structured comprehensively, covering basic theory, laboratory practice, and challenging projects to encourage creativity and technical skills, able to become pioneers in future technological advances.

Basic electronics lectures are often faced with various complex and challenging difficulties. One of the challenges is understanding abstract basic concepts that require deep logical thinking. This electronics lecture is important and applicable whose theory can be applied in life with the electronic devices we use (Parada, 2024; Angelina, et. al, 2024). Students must have strong practical skills. The process of solving problems in electronic circuits can also be very complicated, especially when dealing with damaged components. These factors make electronics lectures one of the fields of study that requires high dedication, perseverance, and the ability to present in many ways.

Prospective physics teacher students have an important role in shaping the next generation who are literate in science and technology. Not only are they required to master physics concepts in depth, but they must also be able to convey the material in a way that is interesting and easy for students to understand. Prospective physics teachers need to develop effective pedagogical skills, such as the ability to design interactive learning, use teaching aids, and apply relevant experimental methods in teaching physics concepts (Khotimah, et. al., 2024; Hayati, et.al., 2020). Students must continue to hone their communication and empathy skills to be able to understand the needs and difficulties faced by students. The challenge of integrating physics theory with innovative teaching practices requires prospective physics teacher students to always learn and adapt to the latest developments in education and technology. Prospective physics teachers will be ready to become inspiring and competent educators, who are able to motivate students to love physics and apply it in their daily lives. In lectures, prospective physics teacher students have different learning styles.

Each individual's learning style can vary greatly, reflecting unique preferences and approaches to processing information. Some people learn more effectively visually, using pictures, graphs, and diagrams to understand concepts, while others may do better with an auditory approach, which involves listening to explanations or discussions (Telaumbanua, et. al., 2024; Ermawati, et. al., 2024). Others prefer a kinesthetic learning style, where they learn by doing, such as through experiments or physical activities that involve movement. In addition, there are those who rely on reading or writing methods, prioritizing notes, lists, and written texts as their primary learning tools. Knowing and understanding one's personal learning style can help one optimize their learning process, improve information retention, and achieve better academic outcomes. It is important for educators to recognize these variations in learning styles and try to adapt their teaching methods to meet the needs of the diverse student body on campus.

Multiple representations is an educational approach that involves using different forms of presenting information to help students understand concepts more comprehensively. This approach can include verbal, visual, symbolic, and manipulative representations that allow students to see concepts from multiple perspectives. For example, in electronics learning, the concept of function can be taught through graphs, equations, data tables, and contextual explanations. The use of multiple representations helps students connect abstract ideas with concrete representations, thereby facilitating deeper and more flexible understanding. This strategy can accommodate a variety of student learning styles, allowing each individual to process information in a way that works best for them (Guentulle, et. al., 2024; Kasaei, et. al., 2023; Ling, et. al., 2024). The application of multiple representations can create a more inclusive and effective learning environment for educators, supporting the development of critical thinking and problem-solving skills.

Basic electronics courses that implement multiple representations can be effective in helping students understand complex and abstract concepts. Electronic concepts are taught through various forms of representation, such as circuit schematics, block diagrams, computer simulations, and practical demonstrations in the laboratory. For example, when studying amplifiers, students not only learn the theory and mathematical equations, but also see the physical circuit directly, analyze the output signal using an oscilloscope, and utilize simulation software to predict circuit behavior (Hoyer, et. al., 2024; Adha, 2024). Students can see the relationship between theory and practical applications, thereby improving their overall understanding and skills. This multiple representations approach also accommodates various learning styles, so that each student can choose the most effective way to learn the material. Thus, electronics courses that adopt this method can produce graduates who are better prepared to face challenges in the world of work and technology.

METHOD

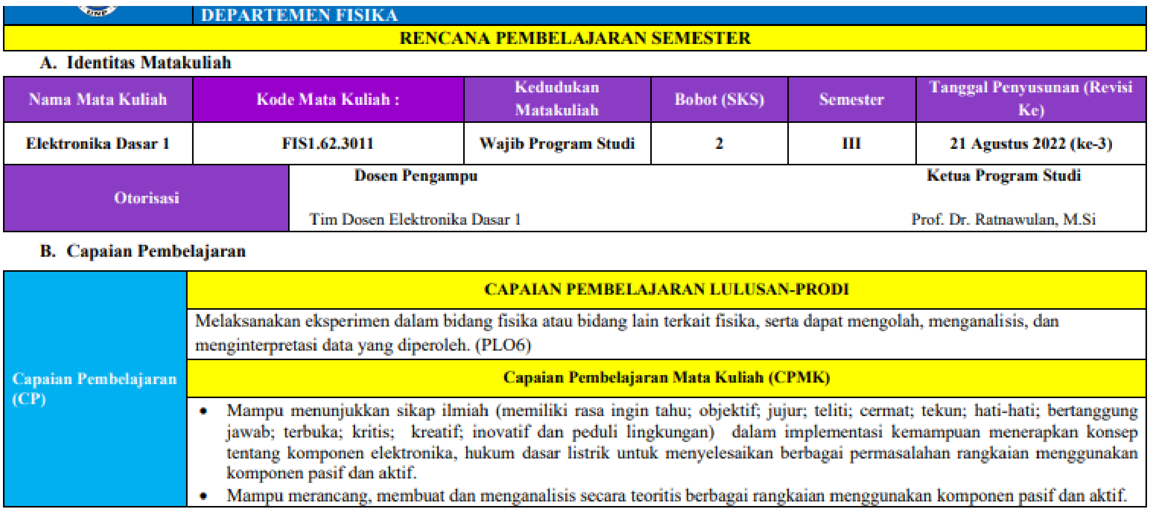
The research method used is mixed methods with triangulation design. Triangulation model, namely document data, interviews, and questionnaires. Quantitative data comes from questionnaire sheets while qualitative data comes from analysis of lecture planning documents, lecturer interviews, and student interviews. The subjects of the study were lecturers teaching basic electronics courses and 50 students of the physics education department at a university in West Sumatra. The data obtained were then analyzed. If the data is still lacking, then additional data is carried out. The final step in implementing this field study is reporting the results so that a lecture profile and the use of multiple representations in basic electronics lectures are obtained. The research procedure can be seen in Figure 1.

Figure 1. Research procedures

RESULTS AND DISCUSSION

1. RPS Analysis

RPS (*Rencana Pembelajaran Semester*/Semester Learning Plan) The basic electronics course analyzed is used in one of the universities in West Sumatra. The components of the RPS for the basic electronics course are complete and refer to the 2022 university curriculum development guidelines. The references used as learning resources are textbooks that contain many symbols. The lecture process is carried out directly, consisting of lectures, discussion activities through discussion forums, studying lecture materials, solving problems, and making resumes. Assessments are carried out on student assignments and activities during lectures. A portrait of the RPS can be seen in Figure 2.



DEPARTEMEN FISIKA

RENCANA PEMBELAJARAN SEMESTER

A. Identitas Matakuliah

Nama Mata Kuliah	Kode Mata Kuliah :	Kedudukan Matakuliah	Bobot (SKS)	Semester	Tanggal Penyusunan (Revisi Ke)
Elektronika Dasar 1	FIS1.62.3011	Wajib Program Studi	2	III	21 Agustus 2022 (ke-3)
Otorisasi	Dosen Pengampu Tim Dosen Elektronika Dasar 1			Ketua Program Studi Prof. Dr. Ratnawulan, M.Si	

B. Capaian Pembelajaran

Capaian Pembelajaran (CP)	CAPAIAN PEMBELAJARAN LULUSAN-PRODI
	Melaksanakan eksperimen dalam bidang fisika atau bidang lain terkait fisika, serta dapat mengolah, menganalisis, dan menginterpretasi data yang diperoleh. (PLO6)
	Capaian Pembelajaran Mata Kuliah (CPMK)
	• Mampu menunjukkan sikap ilmiah (memiliki rasa ingin tahu; objektif; jujur; teliti; cermat; tekun; hati-hati; bertanggung jawab; terbuka; kritis; kreatif; inovatif dan peduli lingkungan) dalam implementasi kemampuan menerapkan konsep tentang komponen elektronika, hukum dasar listrik untuk menyelesaikan berbagai permasalahan rangkaian menggunakan komponen pasif dan aktif. • Mampu merancang, membuat dan menganalisis secara teoritis berbagai rangkaian menggunakan komponen pasif dan aktif.

Figure 2. Portrait of Basic Electronics RPS 1 & 2 (Indonesian Language)

2. Lecturer Interview

The results of an interview with a lecturer teaching basic electromagnetics (BE) are described in Table 1.

Table 1. Results of Interviews with Subject Lecturers

No	Question	Answer
1.	Do you implement active and student-centered learning in BE 1-2 lectures?	Yes, students are expected to be active during lectures and student activity will be assessed.
2.	What learning models are often used in BE 1-2 lectures?	Inquiry learning, but usually the topics studied in class lectures come before the practical work so that students are given the material first before finding out.

No	Question	Answer
3.	What learning methods are used in BE 1-2 lectures?	Interactive lectures, discussions, presentations, and practicals.
4.	What obstacles do you face in teaching MK BE 1-2?	Students still find it difficult to apply basic laws such as Loop Law, Current Law, and Kirchoff's Voltage Law to solve and analyze circuits.
5.	Do you organize practical activities?	Yes. The practicum is supervised by a lecturer and assisted by a Laboratory Assistant..
6.	How has the BE 1-2 practical been implemented so far? (real or virtual)	Real with direct practice in the laboratory.
7.	Does the practical module used contain practical steps, data tables, and guidelines for analyzing data?	Yes.
8.	Are the results of the practical activities confirmed and presented in class?	Of course. After the practicum, usually a presentation is made by a group representative.
9.	Do you use multiple representations in delivering BE 1-2 lectures? What form of representation is most often used?	Of course. In addition to circuit diagrams, they often feature symbols, tables, graphs, and more.
10.	Do you provide self-made teaching materials? What learning resources are used in lectures?	Yes. The practical teaching materials are made by ourselves and have been circulated in bookstores and online bookstores. The practical modules are designed by the teaching team of Basic Electronics Courses 1 and 2.

3. University Student Interview

The results of interviews with 5 students who have taken the electromagnetics course are described in Table 2.

Table 2. University Student Interview Results

No	Question	Answer
1.	Do you understand the BE 1-2 material presented by the lecturer well?	Quite understandable.
2.	Do you actively participate in class?	Quite active and some are less active.
3.	What difficulties did you face in attending BE 1-2 lectures?	Difficulty in understanding equations and deriving formulas, understanding concepts, finding applications of concepts in the real world, imagining abstract phenomena.
4.	What material is the most difficult to understand? Why is that?	Application of Transistors as Switches and Astable Multivibrators because it requires a good understanding to understand the circuit.
5.	What courses are the basis for understanding BE 1-2 material well?	Basic physics and mathematical physics.
6.	How is the practicum carried out?	Direct practice in the laboratory.
7.	Is the BE 1-2 practicum in line with the lecture material?	Some of the material is consistent, but there is some that is unusual because it coincides with the holidays.
8.	Can you be creative in carrying out practical work?	Not enough, because there is already a guide.
9.	Can you relate the material taught in class to the results obtained from the practical activities?	Difficult.
10.	Can you represent the given material in various forms?	Not yet, still having difficulty explaining the material in various representations because I can only use one form of representation.
11.	What representations are most often used in lectures?	The image explains the electronic circuit.
12.	Does the form of representation used make it easier for you to learn BE 1-2 material?	Masih kesulitan

4. Observation

Indirect observation was conducted through a questionnaire distributed to 50 undergraduate students of Physics Education who had taken basic electronics 1 and 2 courses at one of the universities in Padang City, West Sumatra Province. The questionnaire consisted of several indicators, namely learning style of lecture implementation, understanding of basic electronics 1 and 2 materials, implementation of practicums, use of multiple representations, assessment, perception of lecture materials, and perception of material representation. The questionnaire consisted of several statements using a Likert scale and single choice to determine students' perceptions of the materials contained in basic electronics 1 and 2 courses and students' perceptions of the forms of representation used in lectures. Based on the results of data processing, several results or findings were obtained.

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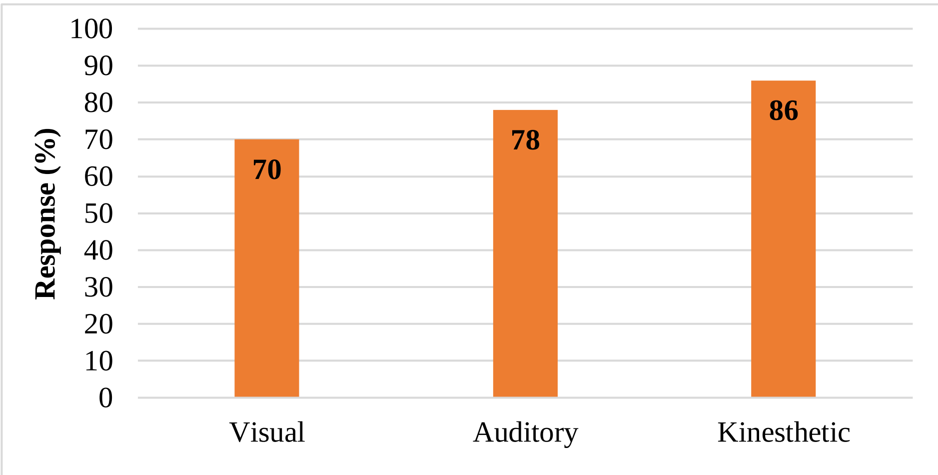

Figure 3. University Students Learning Styles

In Figure 3, many students choose the right learning style to understand basic electronics, namely the kinesthetic learning style, which is 86%. This learning style is very suitable for the character of basic electronics courses that must be carried out directly in understanding the circuit. Being creative in assembling the practicum will make students learn directly and meaningfully.

In the aspect of lecture implementation, there are two indicators that are the focus, namely active learning and the use of methods in lectures. This aspect is important to review more deeply to find out the profile of basic electronics lectures so far. The results obtained in the aspects of learning style and lecture implementation can be seen in Figure 4.

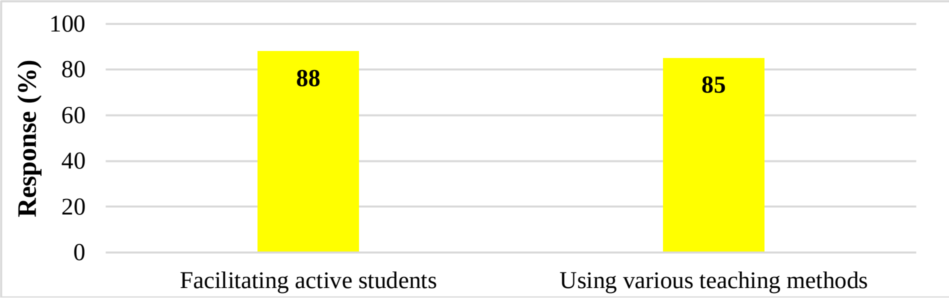

Figure 4. Implementation of BE 1 & 2 Lectures

Figure 3 shows that students have a visual learning style of 70%, an audio learning style of 78%, and a kinesthetic learning style of 86%. This shows that the kinesthetic learning style is very much in demand and needed by students in the lecture process. Figure 4 shows that the implementation of lectures is carried out 88% and the use of teaching materials 85%. This means that in the lecture process the lecturer has facilitated active students and multiple aspects of teaching representation. This statement is also supported by the results of the interview that by implementing active and student-centered learning in basic electronics lectures 1 and 2, the lecturer expects students to be active during the lecture. This is supported by giving more value to students who are active and involved in lectures. However, based on the results of interviews with students, it was found that although most students are active in lectures, there are still students who are rarely active in lectures.

Lecturers facilitate active learning by using various methods in teaching basic electronics 1 and 2, 88% of students agree with this statement. Based on the results of interviews with lecturers, it is known that the lecture model that is often used is inquiry learning with interactive lecture methods, discussions, presentations and practicums. However, this model is not implemented well because the implementation of lectures is usually given before the practicum so that students are given the material first before finding it. The results of the field study on the lecture implementation indicator can be seen in Figure 4.

The implementation of lectures conducted by lecturers greatly influences students' understanding of the materials in electromagnetic lectures. In the aspect of understanding basic electronics materials, four criteria are given that must be selected by students. The results obtained can be seen in Figure 5.

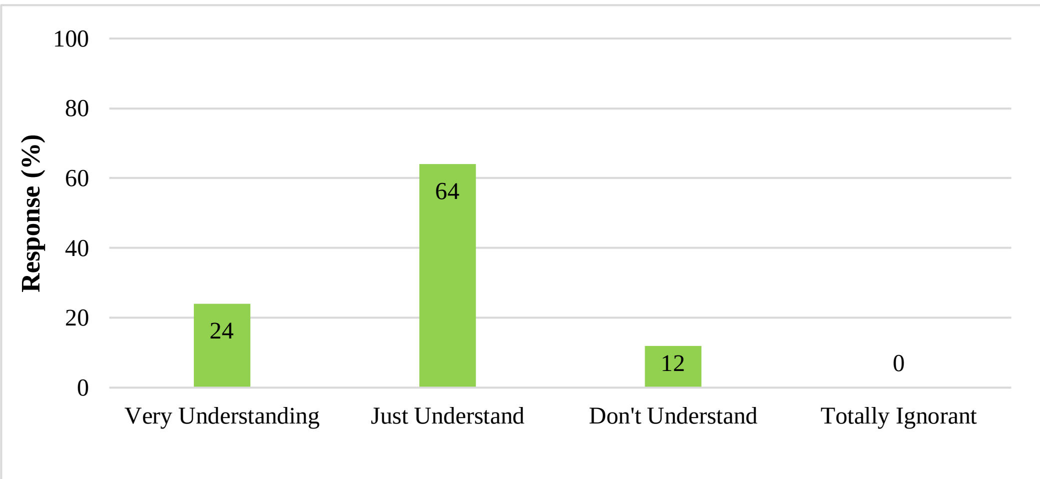

Figure 5. Aspects of Understanding BE 1 & 2 Material

Based on Figure 5, it can be seen that 64% of students stated that they had a good understanding of basic electronics 1 and 2. Similarly, 5 students who were interviewed stated that they had a good understanding of the material presented by the lecturer. This is because they have difficulty in understanding equations, deriving formulas, concepts, finding the application of concepts in the real world, and imagining abstract phenomena. The lecturer also stated that the difficulty faced in teaching the material lies in the insufficient time to teach the material. The lecturer also has difficulty making students understand the concept material because this course contains many symbols and equations.

Deeper knowledge related to the difficulties experienced by lecturers and students, in this field study, students' perceptions of the courses considered the most difficult and important by students were investigated. The materials were arranged based on the order contained in the RPS. The results obtained can be seen in Table 3.

Table 3. Student Perceptions of the Most Difficult and Important Material

No.	Material	Difficult material (%)	Important material (%)
1.	Components and Basic Laws of Electrical Circuits	2	8
2.	Voltage and Current Divider Circuits and Equivalent Circuits	0	8
3.	Capacitor Charging and Discharging Circuit and Wave Changer circuit	4	12
4.	Signal Attenuator (Filter) Circuit	18	14
5.	Electrical Resonance in RLC Circuits and Voltage Transfer	22	22
6.	Diodes as Wave Rectifiers	6	2
7.	Diodes as Wave Formers	2	2
8.	Bipolar Transistors and Their Characteristics	10	10
9.	Transistors as Amplifiers	4	2
10.	Voltage Amplifier Circuit	2	2
11.	Buffer Circuit	6	8
12.	DC Coupled Amplifier Circuit	14	16
13	Transistor Applications as Switches and Astable Multivibrators	58	60
14	Operational Amplifier (Op-Amp)	34	62
15	IC timer NE 555	48	52

Based on Table 3, it can be seen that students have difficulty in understanding the material on the application of transistors as switches and astable multivibrators. However, this material is also important material because it is very closely related to other courses so that it needs to be emphasized to be studied. The results of interviews with students also stated that they had difficulty understanding the material on the application of transistors as switches and astable multivibrators because there were many equations and images that were difficult to understand. In addition, students had difficulty in understanding the material on boundary conditions because it was difficult to determine and imagine real phenomena. In order for them to understand the material well, a mature concept is needed in basic physics and mathematical physics lectures.

The next aspect reviewed is the implementation of practicums in basic electronics lectures 1 and 2. In this aspect, there are 2 indicators, namely the implementation of practicums and the nature of the practicums carried out. The results obtained can be seen in Figure 6..

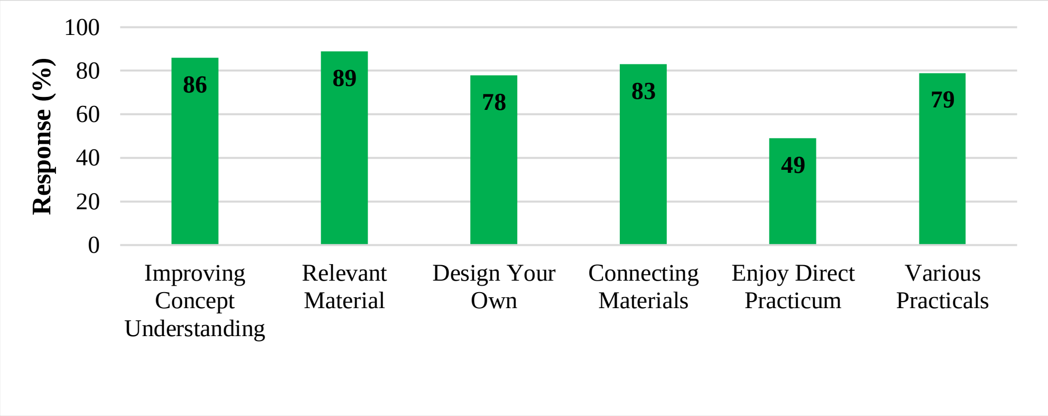

Figure 6. Implementation of Practical Work

Based on the results of interviews with lecturers and students, it can be seen that the implementation of practicums in basic electronics lectures 1 and 2 is carried out directly. 49% of students are happy with the implementation of direct practicums. The practicum module used contains practicum steps, data tables, and there are guidelines for analyzing data so that students cannot be creative in carrying out practicums. 79% of students stated that practicums are only for verification. However, the results obtained from the questionnaire results showed that only 78% of students stated that practicums were carried out by designing their own steps and tables. 83% of students had no difficulty in connecting the material with the results of the practicum.

This is in line with 86% of students stating that they can understand the material being practiced. 89% of students stated that the implementation of the practicum is in line with the lecture material. Lecturers provide the material first and sometimes the practicum is not in accordance with the material given. Lecturers also rarely provide confirmation of the results of the practicum due to time constraints so that students have no difficulty in connecting the material with the concepts obtained from the results of the practicum. Meanwhile, the results of the interview stated that students had a little difficulty in connecting the material taught in class with the results obtained from the practicum activities.

Based on the results obtained, it can be concluded that students consider the materials contained in basic electronics lectures to contain more mathematical and symbolic equations. This is related to the representation used in lectures so that in this field study, the aspect of using multiple representations in lectures is also seen. The results obtained can be seen in Figure 7.

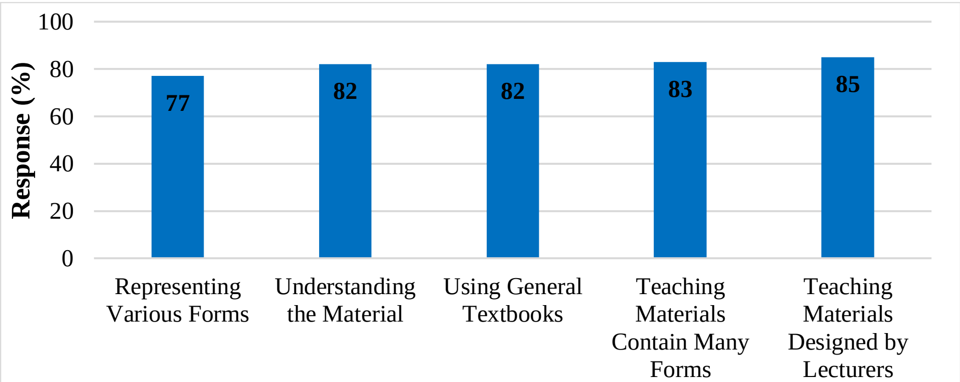

Figure 7. Use of Multiple Representatives

Based on the results in Figure 7, it can be seen that 77% of students are actually able to represent the material in various forms. However, based on the interview results, it was found that some other students also found it difficult to explain the materials in the basic electronics 1 and 2 lectures in various representations. 82% of students felt they understood the material better if the material was represented in various forms. However, this has not been realized because 82% of students stated that in lectures, lecturers only use textbooks as the main reference material. The textbooks used also do not contain many representations. Lecturers have not used teaching materials that they designed themselves. Based on the results of interviews with lecturers, it is known that the learning resources used mostly come from books written by the lecturers themselves and have been published in several stores, both directly and online. The practical module was written by the teaching team of the basic electronics MK. This book still contains few representations and students have difficulty learning it.

Supporting the data that has been obtained, in this field study, students' perceptions of representations that are often used in the lecture process and representations that make it easier for students to understand electromagnetic material are also seen. The results obtained can be seen in Table 4.

Table 4. Student Perceptions of Representations Used in Lectures

No.	Representation	Frequently used representation (%)	Representation makes it easier to understand (%)
1.	Text	72	62
2.	Picture	78	94
3.	Symbolic (Mathematical Equations)	70	60
4.	Chart	44	44
5.	Table	24	28
6.	Numeric	24	16

Based on Table 4, it can be concluded that the most frequently used representation in basic electronics lectures is images. This is supported by the results of interviews that in delivering BE 1 & 2 lectures, lecturers only use several multiple representations. The most frequently used representations are words and images because BE 1 & 2 materials contain many circuit images. Students also stated that the representations that are often used are symbols and sometimes graphs. However, students think that they will find it easier to understand the material if the material is presented in the form of images and graphs. Students also stated that if all forms of representation are used in explaining BE 1 & 2 materials, the material will be easier to understand, students will find it easier to imagine phenomena that are in accordance with the concept, and the application of the concept will be clearer.

The last aspect reviewed is the assessment applied in lectures. In this aspect, it will be seen how the lecturer gives the assessment and what competencies are assessed by the lecturer. The results obtained are shown in Figure 8.

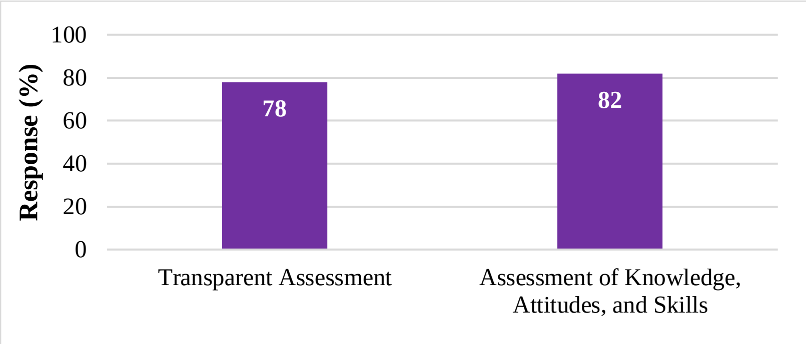

Figure 8. Lecturer Assessment

Based on Figure 8, 78% of students stated that the lecturer had given marks transparently. Additional marks such as activeness were also stated clearly in front of the class. 84% of students also stated that the assessment conducted by the lecturer included knowledge, attitude, and skill competencies.

CONCLUSION AND SUGGESTIONS

Based on the focus of observation and the results of data analysis that have been carried out, several conclusions can be obtained from the results of this field study, namely that basic electronics lectures 1 and 2 have so far used interactive lecture methods, discussions, and presentations more often. Practical activities are carried out through direct practicums, but the practicums chosen are not in accordance with the lecture material taught. The practicum guide is still in the form of a match so that students must follow the guide until the data analysis process. The references used in lectures refer more to textbooks that do not contain multiple representations. Students prefer basic electronics lectures using various representations. Further research suggestions need to be developed a basic electronics lecture with multiple representations to improve the understanding of physics students and improve the skills needed in the 21st century.

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